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(54) Electric ignition system for a projectile with explosive charges in tandem

(57) An ammunition arrangement in the form of a shell (1) or similar comprising a front and a rear explosive charge (2, 3) is described. In order to prevent the rear explosive charge (3), when attacking a target, being damaged or incapacitated by defensive measures, such as shrapnel from explosive armour, the front part and/or jacket of the rear explosive charge is equipped with a contact sensor (5) which directly initiates the explosive charge (3) without waiting for the elapse of a predetermined time delay normally intended to delay the initiation of the rear warhead (3) relative to initiation of the front warhead (2).

It is suggested that Figure 1 should accompany the abstract.

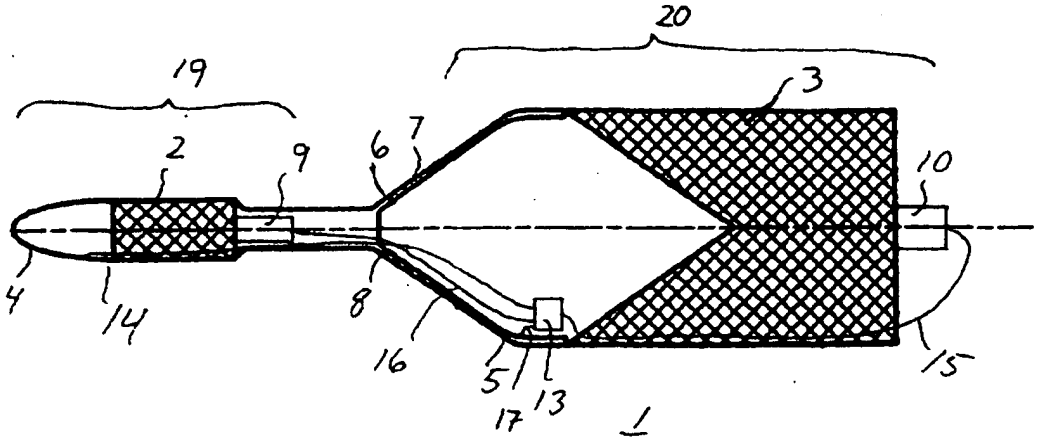

Fig. 1

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Description

[0001] The present invention relates to an ammunition arrangement in the form of a shell or similar comprising at least a first and a second warhead situated axially behind one another and at least one delay arrangement. The first warhead constitutes the front warhead of the ammunition arrangement with a first explosive charge and a first sensor arrangement and the second warhead constitutes the rear warhead of the ammunition arrangement with a second explosive charge and a second sensor arrangement. At least one explosive charge situated behind the first warhead is initiated either at the expiry of a predetermined time delay determined by the delay arrangement after the detection of a hit by the sensor arrangement for an explosive charge situated in front or at the time of the detection of a hit by the explosive charge's sensor, whichever is the earlier.

[0002] An ammunition arrangement of this kind is previously known through European Patent B1 0497394. In this case hits are detected through the sensing of shock waves by means of piezoelectric crystals. A piezoelectric crystal adjacent to the rear explosive charge is thereby used both to determine the time of impact of the front explosive charge on a target, thereby starting the measurement of time in the time delay arrangement, and for the detection of a new shock wave, caused for example by explosive armour, for the direct initiation of the rear explosive charge. The known ammunition arrangement, however, exhibits a number of limitations affecting, for example, speed of operation, differential resolution and flexibility. The known ammunition arrangement is incapable of differentiating between shock waves occurring with a short time delay between, but requires the first shock wave to have subsided in the arrangement before the arrangement can once again be made ready to sense new shock waves. The rear explosive charge is thereby insensitive to direct initiation immediately following initiation of the front explosive charge. In the event that the shock wave for the initiation of the front explosive charge is absent, no initiation of the rear explosive charge takes place if it is subjected to a hit. In this case, initiation of the rear explosive charge requires the sensor element to be subjected to double shock waves well separated in time.

[0003] The purpose of the present invention is to produce an ammunition arrangement which does not exhibit the aforementioned limitations.

[0004] The purpose of the invention is achieved by means of an ammunition arrangement characterized in that at least one sensor arrangement associated with a warhead situated behind the first warhead comprises a contact sensor adjacent to the front part of that warhead and/or jacket. The term contact sensor as used both above and in the following description includes sensors having the function of either closing or breaking a circuit or combinations of these functions. Through the invention the ammunition arrangement's second explosive charge in the rear warhead is made capable of direct initiation throughout the attack phase. An ammunition arrangement in accordance with the invention in the form of a contact sensor provides rapid and adequate initiation of the charge when it is subjected to a hit, for example in the form of shrapnel from explosive armour or the like.

[0005] In this context it can be stated that it is previously known per se, that in a shell with two explosive charges, the rear explosive charge can be equipped with a sensor arrangement in the form of a contact sensor, see European Patent B1, 0 238 715. In this case, however, it is a question of two explosive charges which are initiated quite independently of each other. The rear explosive charge is not initiated until its contact sensor make contact with the target. The time difference between the initiation of the explosive charges arises due to the path difference between the sensor arrangements of the explosive charges. The written description does not in any way touch upon the problem of explosive armour. If the rear explosive charge is hit before the front explosive charge is hit, the effect of the rear charge is affected in that it is then fired into the front explosive charge.

[0006] Furthermore, double-shelled contact sensors intended for applications including shells have been described in Swedish Patent Application SE 9501603-6. Activation principles for double explosive charges are not, however, touched upon.

[0007] According to a suitable embodiment, the contact sensor is arranged, when a hit is detected, to initiate all warheads in front of it. This embodiment ensures that those explosive charges lying in front of it are removed from the path of the contact sensor's explosive charge.

[0008] According to another suitable embodiment, a constituent contact sensor comprises two or more concentric and mutually insulated shells the impedance characteristics of which are sensed. This embodiment permits a relatively large sensing surface to be achieved by simple means.

[0009] According to yet another suitable embodiment which permits a large sensing surface area, a constituent contact sensor comprises one or more electrically conducting coils the impedance characteristics of which are sensed. The electrical coils may then advantageously be positioned round an essentially cylindrical part of the jacket of the ammunition arrangement.

[0010] According to yet a further advantageous embodiment, a constituent contact sensor comprises an outer and an inner shell arranged essentially cylindrically and forming a shoulder-like front part of an explosive charge situated behind the front warhead. This embodiment permits simple integration into designs involving two or more explosive charges with minimal effect on the other properties of the ammunition arrangement such as air resistance etc. This embodiment also permits the inner shell to be formed as part of the warhead structure.

[0011] According to yet a further advantageous embodiment, a constituent sensor comprises two concentric and essentially cylindrical shells arranged round an essentially cylindrical part of the jacket surrounding a warhead situated behind the front warhead. This embodiment gives a large sensing surface area. In order to reduce the risk of the warhead charge being damaged in the event of a hit, it is an advantage for the inner of the contact sensor's two cylindrical shells to be located at a distance from the warhead's explosive charge.

[0012] The invention is suitable both for embodiments with two warheads and for embodiments with three or more warheads. An advantageous embodiment with at least three warheads is characterized in that at least two of the warheads situated behind the front warhead are equipped with sensor arrangements comprising contact sensors adjacent to the front part of the respective warhead and/or jacket.

[0013] According to one embodiment, the predetermined time delay following the detection of a hit by the sensor arrangement for an explosive charge in front is related to the initiation of the nearest explosive charge in front and, in another embodiment, related to the initiation of the first explosive charge.

[0014] According to a compact and apt embodiment of the ammunition arrangement, the delay arrangements associated with the warhead(s) situated behind the first warhead are arranged in a space in the rear warhead and within its sensor arrangement.

[0015] According to another compact and apt embodiment of the ammunition arrangement, the delay arrangements associated with the warheads are situated in the space of the respective warhead in front of the explosive charge and within its sensor arrangement.

[0016] The invention will be described in more detail below by means of exemplary embodiments with reference to the attached drawings in which:

[0017] Figure 1 shows in cross section a schematic first example of an ammunition arrangement according to the invention in the form of a shell with a front and a rear explosive charge.

[0018] Figure 2 shows schematically and in cross section the front part of the rear explosive charge constituent in the ammunition arrangement according to Figure 1.

[0019] Figure 3 shows a partial cross-sectional view of another example of an ammunition arrangement according to the invention with two warheads.

[0020] Figure 4 shows schematically and in block form an example of an electronic part which can be incorporated in an ammunition arrangement according to the invention with two warheads.

[0021] Figure 5 shows a partial cross-sectional view of a schematic first example of an ammunition arrangement according to the invention with three warheads.

[0022] Figure 6 shows a partial cross-sectional view of a schematic second example of an ammunition arrangement according to the invention with three warheads.

[0023] Figure 7 shows a first example of an electronic part which can be incorporated in an ammunition arrangement according to the invention with three warheads.

[0024] Figure 8 shows a second example of an electronic part which can be incorporated in an ammunition arrangement according to the invention with three warheads.

[0025] Figure 1 shows an ammunition arrangement in the form of a shell 1 with a front warhead part 19 comprising a front explosive charge 2 and a rear warhead part 20 comprising a rear explosive charge 3. At least the rear explosive charge will preferably be of the jet-forming or projectile-forming type of shaped charge.

[0026] The front explosive charge 2 is equipped with a sensor arrangement 4 of some conventionally known kind and is therefore not shown in greater detail. The sensor arrangement can also be built up according to the principles described below for the sensor arrangements situated behind. The sensor arrangement 4 initiates, on contact with the target and/or shrapnel hit, the ignition of the front explosive charge 2 and starts the time delay for initiation of the rear explosive charge.

[0027] The rear explosive charge 3 is equipped with a sensor arrangement 5 situated adjacent to the front part of the rear explosive charge. The sensor arrangement is of the contact type and consists, as is more clearly evident from Figure 2, of an inner and an outer shell 6 and 7 respectively, separated by an insulating space 8. Shells 6, 7 have limiting surfaces shaped in the form of the surface of a truncated cone. The outer shell 7 also constitutes the outer limit for the front part of the rear explosive charge. The insulating space 8 can be filled with air or other suitable insulating material. The inner shell 6 can be formed as part of the warhead structure.

[0028] Furthermore, the explosive charges 2, 3 each include their detonating arrangements 9,10 with ignition and safety functions situated adjacent to the rear part of the respective explosive charge. The detonating arrangements 9,10 is initiated from the sensor arrangements 4,5. A cable 14 connects the sensor arrangement 4 with an electronic circuit 13. A cable 17 connects the sensor arrangement 5 with the same electronic circuit 13. The detonating arrangements 9 and 10 are connected to the electronic circuit 13 by cables 15, 16.

[0029] The electronic circuit 13 comprises, see Figure 4, a delay arrangement 11 and a logic circuit in the form of two OR-gates 12,18. A space formed between the sensor arrangement 5 and the front part of the rear explosive charge is arranged to contain the electronic circuit.

[0030] The function of the shell is described below with reference to Figure 4.

[0031] When the shell 1 reaches a target, the sensor arrangement 4 detects target contact and the front explosive charge is initiated via the detonating arrange-

ment 9. Coincident in time with the initiation of the front explosive charge 2, a delay arrangement 11 is started from the sensor arrangement 4.

[0032] Following initiation of the front explosive charge, events can follow two different courses.

[0033] According to a first course of events, the sensor arrangement 5 is not subjected to shrapnel from explosive armour or other effect which leads to contact between the sensor arrangement's two shells prior to the initiation of the explosive charge 3. In this case, the rear explosive charge 3 is initiated via the detonating arrangement 10 of the electronic circuit 13 only after the elapse of a time delay predetermined by the delay arrangement 11.

[0034] If, however, according to a second course of events, the sensor arrangement 5 in front of the rear explosive charge is subjected, prior to the initiation of the rear explosive charge via the delay arrangement 11, to hits which cause a short circuit between the sensor arrangement's two shells, the rear explosive charge is initiated directly via the OR-gate 12 and the detonating arrangement 10.

[0035] If the shell reaches a target and the sensor arrangement 5 detects target contact before the sensor arrangement 4, both the front explosive charge, via the detonating arrangement 9, and the rear explosive charge, via detonating arrangement 10, will immediately be initiated.

[0036] In the example of an ammunition arrangement with two warhead parts 19, 20 shown in Figure 3, the rear warhead part 20 has been equipped with a sensor arrangement which also comprises two concentric, essentially cylindrical shells 21, 22. Between these shells 21, 22 there is a layer of air or other insulating material. These shells 21, 22 are fitted round a cylindrically shaped part of the jacket of the rear warhead part 20. Shrapnel or the like which hit shells 21, 22 cause a short circuit between the shells. This short circuit is identifiable as a clear change in impedance. According to the example of embodiment shown, the shells are arranged at a distance from the explosive charge 3 and are separated by a layer 24 which, for example, have a thickness of several tens of millimetres, e.g. 50 mm. As a result of the introduction of this layer 24, which can for example consist of air, there is a greater possibility of being able to detonate the explosive charge 3 before shrapnel, which hit the sensor arrangement, can reach the explosive charge 3.

[0037] Figure 5 shows a first example of an ammunition arrangement with three warhead parts 30, 40, 50 containing explosive charges 31, 41, 51. The intermediate and rear explosive charges 41, 51 are in this case equipped with a number of electrically conducting coils 42 and 52 surrounding a cylindrically shaped part of the respective warhead jackets. The coils are enclosed within insulating layers 43, 53. The coils form part of an associated sensor arrangement of which the impedance characteristics are sensed.

[0038] In the space in front of the explosive charge 41 of the intermediate warhead 40, there is fitted an electronic part 44. Similarly, an electronic part 54 is fitted in the space in front of the explosive charge 51 of the rear warhead 50. The electronic parts 44, 54 are connected with the sensor arrangements 35; 42, 45; 52,55 and the detonating arrangements 36, 46, 56. The initiation sequence is described in more detail later with reference to Figure 7.

[0039] The second example of an ammunition arrangement with three explosive charges shown in Figure 6 differs from the first example in that the electronic parts are assembled in a common electronic part 54 fitted in the space in front of the explosive charge 51 of the rear warhead 50. The initiation sequence is described in more detail later with reference to Figure 8.

[0040] According to Figure 7 the intermediate warhead comprises an electronic part 44 and the rear warhead an electronic part 54. The electronic part 44 incorporates a delay arrangement 64 and two OR-gates 61, 62. The electronic part 54 comprises a delay arrangement 65 and an OR-gate 63.

[0041] An ammunition arrangement which reaches its target without being hit by shrapnel or the like is initiated by the sensor arrangement 35 which immediately causes detonation of the explosive charge 31, detonation of the explosive charge 41 after a time delay $\tau 1$ introduced through the delay circuit 64 and detonation of explosive charge 51 after a further time delay $\tau 2$ introduced through the delay circuit 65.

[0042] In the event that the sensor arrangement 42, 45 of the intermediate warhead is hit, the explosive charges 31 and 41 are immediately detonated while the explosive charge 51 waits for a time delay $\tau 2$ in the delay circuit 65 before it detonates. If the sensor arrangement 52, 55 detects a hit during the time delay $\tau 2$ in the delay circuit 65, explosive charge 51 is detonated directly.

[0043] If the sensor arrangement 52, 55 of the rear warhead detects a hit first, all three explosive charges 31, 41, 51 are immediately detonated.

[0044] In the example shown in Figure 8, the ammunition arrangement has been equipped with a common electronic part 54 fitted in a space in the rear warhead. The electronic part comprises components corresponding to those in the electronic parts 44 and 54 described with reference to Figure 7. The time delay sequence for the rear warhead 51, however, is in this case initiated directly from the sensor arrangement 35. The time delay introduced by the delay circuit 65 is in this case suitably longer than $\tau 1$ and can, for example, amount to a delay corresponding to $\tau 1 + \tau 2$ for the exemplary embodiment according to Figure 7.

[0045] It can be observed that the logic functions according to the Figures 7 and 8 can also be applied in reverse in the ammunition arrangements described with reference to Figures 5 and 6.

Claims

1. Ammunition arrangement in the form of a shell or similar comprising at least a first and a second warhead situated axially behind one another and at least one delay arrangement, in which the aforementioned first warhead constitutes the front warhead of the ammunition arrangement with a first explosive charge and a first sensor arrangement and in which the aforementioned second warhead constitutes the rear warhead of the ammunition arrangement with a second explosive charge and a second sensor arrangement and in which at least one explosive charge situated behind the first warhead is initiated either at the expiry of a predetermined time delay determined by the delay arrangement after the detection of a hit by the sensor arrangement for an explosive charge situated in front or at the time of the detection of a hit by the explosive charge's sensor, whichever is the earlier, characterized in that at least one sensor arrangement associated with a warhead situated behind the front warhead comprises a contact sensor adjacent to the front part of the warhead and/or jacket.

2. Ammunition arrangement according to Claim 1, characterized in that the contact sensor, on detecting a hit, is arranged to initiate directly all warheads situated in front of it.

3. Ammunition arrangement according to any of the preceding claims, characterized in that a constituent contact sensor comprises two or more concentric and mutually insulated shells of which the impedance characteristics are sensed.

4. Ammunition arrangement according to any of the preceding claims, characterized in that a constituent contact sensor comprises one or more electrically conducting coils of which the impedance characteristics can be sensed.

5. Ammunition arrangement according to Claim 4, characterized in that the electrical coils are arranged round an essentially cylindrical part of the jacket of the ammunition arrangement.

6. Ammunition arrangement according to any of the preceding claims, characterized in that a constituent contact sensor comprises an outer and an inner shell which are essentially concentrically arranged and which form a shoulder-shaped front part of a warhead situated behind the front warhead.

7. Ammunition arrangement according to any of the preceding claims, characterized in that a constituent contact sensor comprises two concentric essentially cylindrical shells arranged round an essentially cylindrical part of the jacket of a warhead situated behind the front warhead.

8. Ammunition arrangement according to Claim 7, characterized in that the inner of the contact sensor's two cylindrical shells are arranged at a distance from the warhead's explosive charge.

9. Ammunition arrangement according to any of the preceding claims, characterized in that at least three warheads are arranged to be situated behind one another.

10. Ammunition arrangement according to Claim 9, characterized in that at least two of the warheads situated behind the front warhead are equipped with sensor arrangements comprising contact sensors adjacent to the front part of the respective warhead and/or jacket.

11. Ammunition arrangement according to either of Claims 9 or 10, characterized in that the predetermined time delay after the detection of a hit is related to the initiation of the first explosive charge.

12. Ammunition arrangement according to either of Claims 9 or 10, characterized in that the predetermined time delay after the detection of a hit is related to the initiation of the explosive charge nearest in front.

13. Ammunition arrangement according to any of the preceding claims, characterized in that the time delay arrangements associated with the warhead(s) situated behind the first warhead are arranged in a space in the rear warhead and within its sensor arrangement.

14. Ammunition arrangement according to any of Claims 1-12, characterized in that the delay arrangements associated with the warheads are arranged in spaces in the respective warheads in front of the explosive charge and within the sensing arrangement.

15. Ammunition arrangement according to any of Claims 1-8, 11, 13, characterized in that two warheads are arranged to be situated behind one another.

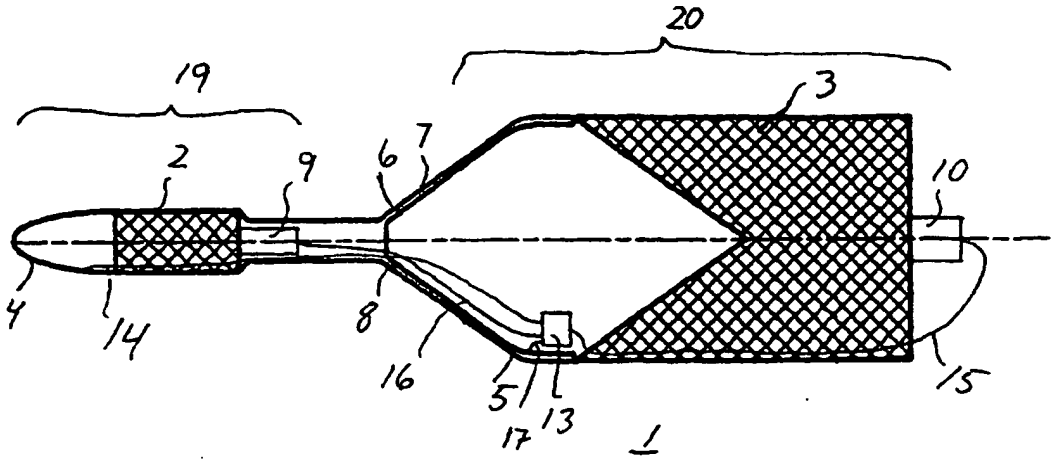

Fig. 1

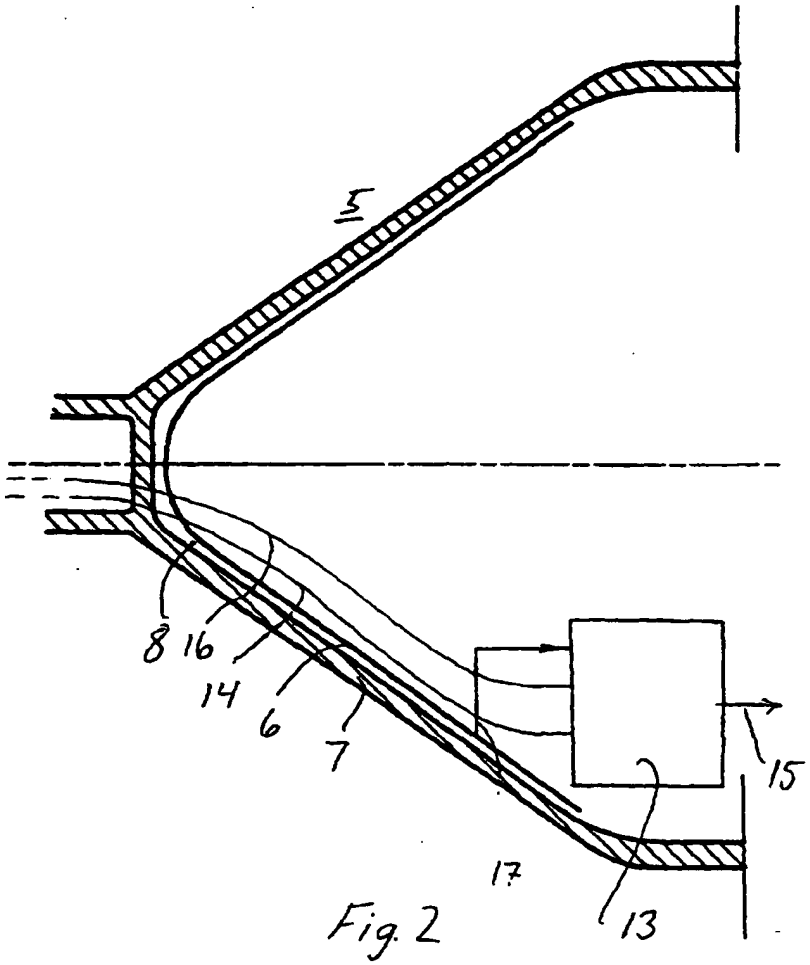

Fig. 2

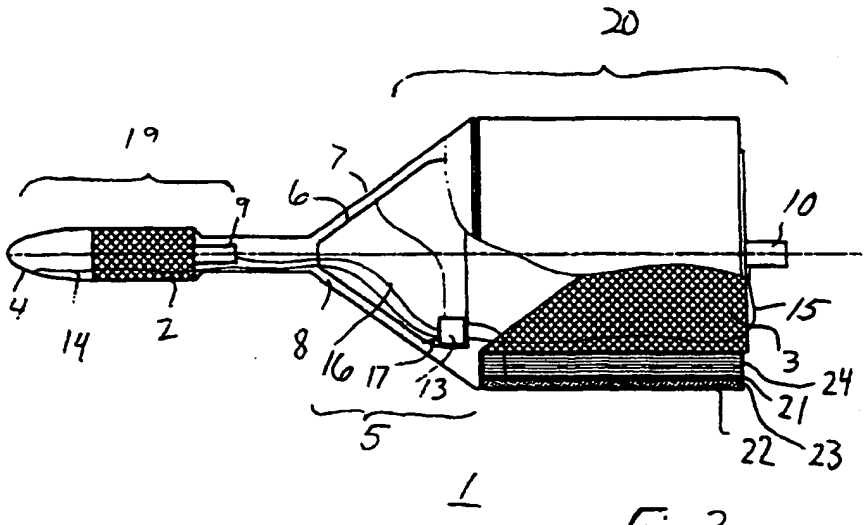

Fig 3

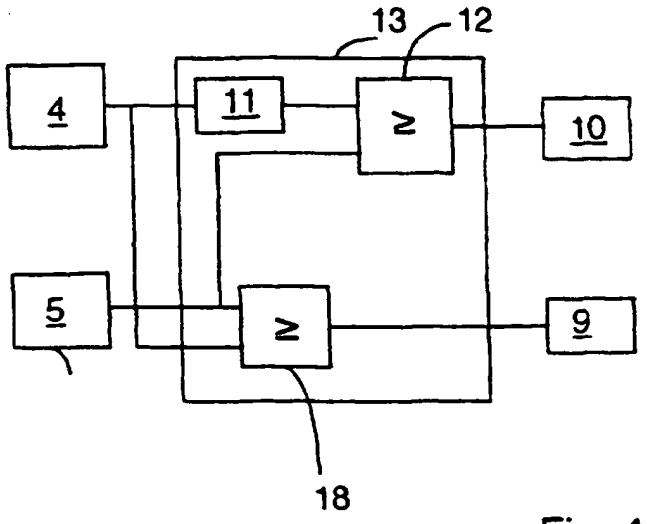

Fig. 4

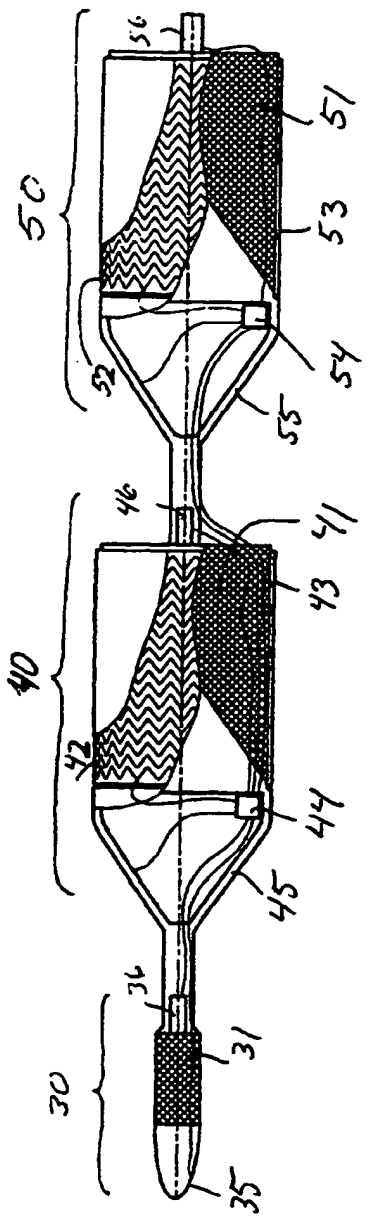
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Fig. 5

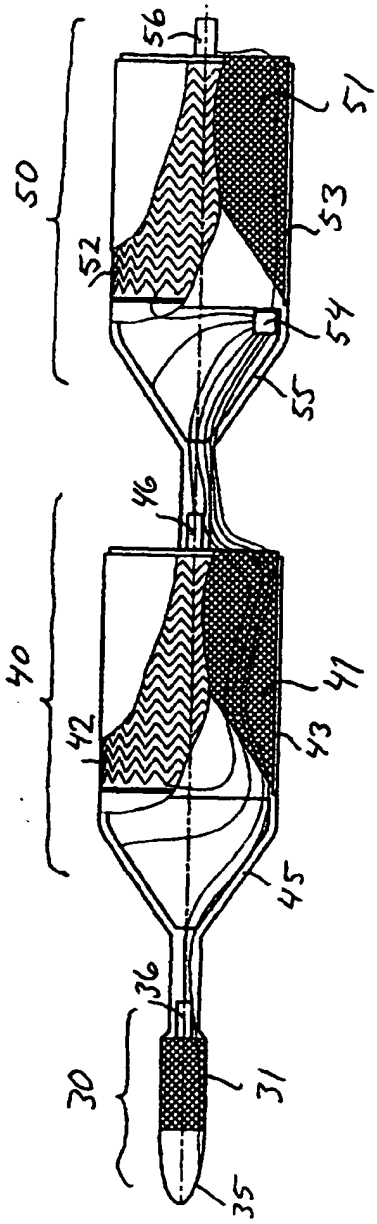
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Fig. 6

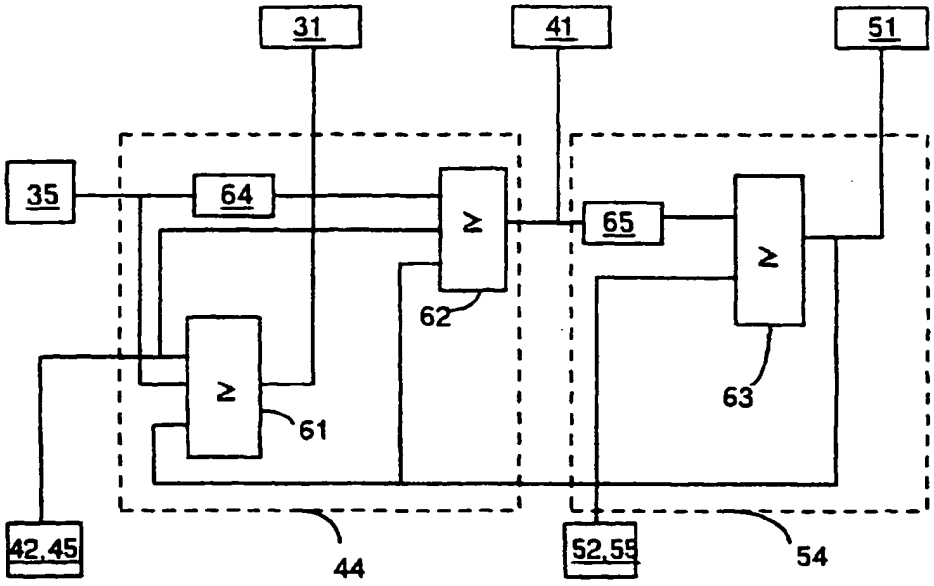
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Fig. 7

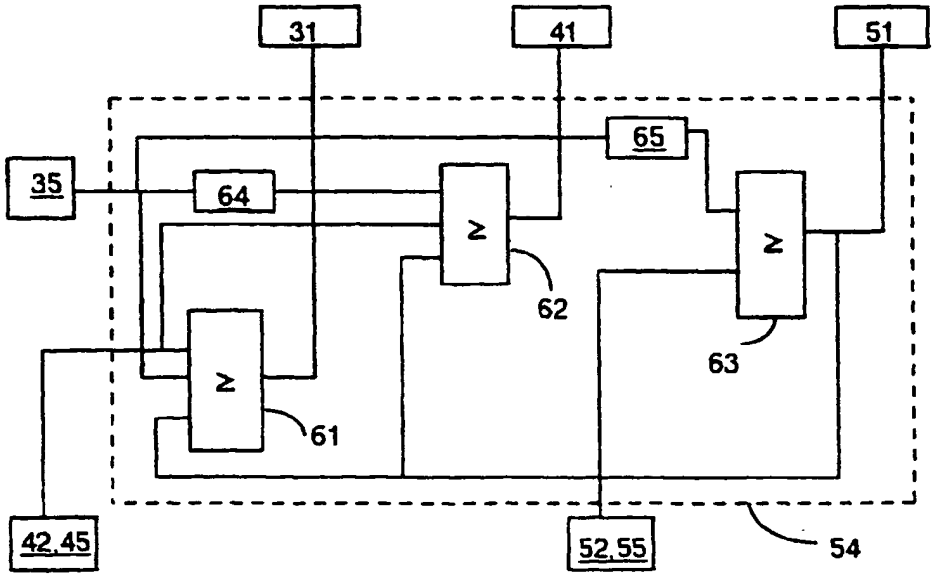
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Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 00 85 0009

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	DE 38 28 142 C (DEUTSCHE AEROSPACE) 11 May 1994 (1994-05-11) * column 2, line 56 - column 3, line 65; figures 1-5 *	1,3,6-8, 13-15	F42B12/18 F42C19/06 F42C11/06
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D,A	EP 0 497 394 A (BOFORS AB) 5 August 1992 (1992-08-05) * column 3, line 29 - column 4, line 39; figure 1 *	1	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 June 2000	Van der Plas, J

CATEGORY OF CITED DOCUMENTS

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